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# Smoking-based selection and influence in gender-segregated friendship networks: a social network analysis of adolescent smoking

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## ABSTRACT

**Aims** The main goal of this study was to examine differences between adolescent male and female friendship networks regarding smoking-based selection and influence processes using newly developed social network analysis methods that allow the current state of continuously changing friendship networks to act as a dynamic constraint for changes in smoking behaviour, while allowing current smoking behaviour to be simultaneously a dynamic constraint for changes in friendship networks. **Design** Longitudinal design with four measurements. **Setting** Nine junior high schools in Finland. **Participants** A total of 1163 adolescents (mean age = 13.6 years) who participated in the control group of the ESFA (European Smoking prevention Framework Approach) study, including 605 males and 558 females. **Measurements** Smoking behaviour of adolescents, parents, siblings and friendship ties. **Findings** Smoking-based selection of friends was found in male as well as female networks. However, support for influence among friends was found only in female networks. Furthermore, females and males were both influenced by parental smoking behaviour. **Conclusions** In Finnish adolescents, both male and female smokers tend to select other smokers as friends but it appears that only females are influenced to smoke by their peer group. This suggests that prevention campaigns targeting resisting peer pressure may be more effective in adolescent girls than boys.

**Keywords** Adolescent smoking, gender differences, peer influence, peer selection, SIENA, social networks.

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## INTRODUCTION

Cigarette smoking continues to be one of the main preventable causes of cancer, heart disease and premature death [1–4]. During adolescence many youngsters experiment with smoking, which may lead to regular smoking [5].

Numerous studies report smoking behaviour to be similar among friends [6–9]. Although early research argued predominantly that similarity was caused by peer influence, recent studies have provided evidence that similarity is also caused by selection of similar friends [10–17]. Friendships are an important aspect of an adolescent's life. Children tend to associate mainly with same-sex others and most close friends are of the same

gender [18]. Although cross-gender friendships begin to develop during adolescence, gender similarity among friends is still marked [19,20]. Same-gender peer relationships are an important socializing context that influences the development of gender differences in social interaction styles. Differences between female–female and male–male friendships may lead to differences in smoking-based selection and influence processes. This study aims to examine selection and influence processes, differentiated by gender, in the context of smoking behaviour among adolescent friendship networks.

Researchers have demonstrated that friendship patterns differ for adolescent males and females. Females have more intimate friendships [18,21,22], report higher intimacy levels [22] and are more likely to turn to peers

for support [23], which could result in more opportunities for influence. Furthermore, previous research has found that females perceived more social pressure to smoke [24,25] and were more susceptible to social influences [26]. However, to our knowledge, no study has examined specifically differences between adolescent male and female friendship networks regarding smoking-based selection and influence processes.

The present study will examine selection and influence processes in male and female networks by using new methods of social network analysis [27,28] which, contrary to conventional methods [10,12], allow the current state of continuously changing friendship networks to act as a dynamic constraint for changes in smoking behaviour, while allowing smoking behaviour to be simultaneously a dynamic constraint for friendship changes. The possibility of unobserved changes in friendships and smoking between two observations is considered and as well as including other possible determinants of smoking behaviour, such as age, parental and sibling smoking [29], these methods allow controlling for other determinants of friendship selection besides smoking-based selection of friends. Some of these determinants are reciprocation of friendship; becoming a friend of somebody who is a friend of a friend [30,31]; and selection based on alcohol consumption [27], age, ethnicity and education [20].

We hypothesize that smoking-based selection will be present in males and females and that females will be more susceptible to influence. Furthermore, we will explore the impact of reciprocity of friendship on the strength of smoking-based selection and influence.

## METHODS

### Participants

The sample comprised 1163 Finnish adolescents who participated as a control group in the ESEA (European Smoking prevention Framework Approach) study [32,33]. Participating schools were based on a random selection of communities in the Helsinki region and had a 50% chance of becoming an experimental school. Only control schools that participated at all four measurements and encompassed a minimum number of 20 males and females were included, resulting in nine schools including 605 males (mean age = 13.62 years) and 558 females (mean age = 13.57 years).

### Procedure

Self-administered questionnaires were distributed among all 7th graders of participating schools. Similar questionnaires were distributed during follow-up among 8th (12-month follow-up) and 9th (24 and 30 months'

follow-up) graders [32,33]. Students present on the days of data collection completed the questionnaire. It was explained that responses would be treated confidentially. Students could refuse to participate, and returned questionnaires in sealed envelopes to guarantee anonymity. At baseline, the proportion of refusals was 0.03% [32].

### Questionnaire

The ESEA questionnaire was based upon earlier studies about adolescent smoking [33–38].

- *Friendship ties* were assessed by asking adolescents to name up to five best friends inside and/or outside school [39]. Only best friends inside the same school grade are included, as only they also completed the questionnaire.
- *Smoking behaviour of adolescents* was assessed by one question: 'On average, how many cigarettes do you smoke during a week (also count the weekend)?' (0 = none, 1 = between none and one, 2 = two to 10, 3 = 11–30, 4 = >30).
- *Parental smoking behaviour* was measured by two questions: 'Does your father (male caregiver) smoke?' and 'Does your mother (female caregiver) smoke?', and was recoded into one variable (0 = neither smokes, 1 = at least one smokes).
- *Sibling smoking behaviour* was measured by two questions: 'Do one or more of your brother(s) smoke?' and 'Do one or more of your sister(s) smoke?', and was recoded into one variable (0 = no siblings smoke, 1 = at least one smokes).
- *School achievement* was assessed by one question: 'Last year, how well did you do in school, compared to the others in your class?' (1 = among the lower third of my class, 2 = the middle third, 3 = the best third).
- *Alcohol consumption* (0 = 0 glasses of alcoholic drinks per week, 1 = one or two glasses, 2 = three to five, 3 ≥ five); *age* (in years) was also recorded.

### Analysis plan

A stochastic actor-based model [28,40–42] was constructed to represent realistically mutual dependencies between friendship changes and changes in smoking behaviour by a simulation model. This model takes into account the mutual feedback processes between friendship and smoking occurring between observations. This new approach was applied successfully to delinquency [31] and alcohol consumption [43]. All respondents were included and allowed to enter the study later or leave earlier [44]. Missing values on adolescents' attributes and smoking behaviour were allowed and treated as non-informative in the estimation procedure and imputed by the mean for the start of the simulations [45]. The model

encompasses two parts: one part models friendship network changes (selection processes), the other part models smoking behaviour changes (influence processes). Both parts are integrated as one internally dependent process. In this manner, selection and influence processes can be examined simultaneously while controlling either process for the other one. Mathematical specifications are given by [28,40] and a sketch of the model is described in the next section.

#### **Friendship network changes: selection processes**

The friendship network evolution part of the model specifies the preferred direction of friendship change by including effects that determine probabilities of changes in friendship status, such as current network structure and adolescent's attributes. Four main smoking-based friendship selection components were included: the effect of adolescent's smoking behaviour on number of friends chosen (smoking behaviour ego); the effect of potential friends' smoking behaviour (raw as well as squared value) on choosing them (smoking behaviour alter, smoking behaviour squared alter); and the interaction between smoking behaviour of adolescents and potential friends, to test that adolescents who smoke more also prefer friends who smoke more (smoking behaviour ego  $\times$  alter). We included the raw and squared value of alters' smoking to control for possible curvilinear dependence of the attractiveness of potential friends on their smoking behaviour. Because friendship choices depend strongly upon characteristics of the current network [20,40,46], the effects of number of friends chosen (outdegree), number of reciprocal friends chosen (reciprocity) and number of friends chosen who are also a friend-of-a-friend (transitivity) were included. The selection model controlled for alcohol consumption, age, and school achievement of adolescents and potential friends. All included effects are presented in the upper part of Table 1.

#### **Smoking behaviour changes: influence processes**

The smoking behaviour evolution part of the model specifies the preferred direction of change in smoking behaviour by including a list of functions of network, smoking behaviour and other attributes upon which changes in smoking behaviour may depend. Included effects are described in the lower part of Table 1. Three main friendship network-related influence components were modelled: the effect of friends' average smoking behaviour, effect of the number of received friendship nominations (incoming friendships) and the number of outgoing friendship nominations on adolescent smoking behaviour (outgoing friendships). Included control effects were the tendency to smoke, a feedback effect of own

previous smoking behaviour to control for non-linearities in smoking (tendency to smoke squared), parental and sibling smoking and adolescents' alcohol consumption, age and school achievement.

#### **Analysis**

For each wave, a female and male network were constructed within each school. All female adolescents would be members of the female network, all males formed the male network. As the focus of the present paper was upon same-gender friendships, cross-gender friendships were excluded. For each network, the dynamic actor-based model was analysed using SIENA (Simulation Investigation for Empirical Network Analysis) software [44]. Effects were tested on the basis of *t*-ratios defined as estimate divided by standard error, which follow an approximate standard normal distribution [40]. Subsequently, results of all network analyses were combined for males and females in two meta-analyses. The null hypothesis that the effect is 0 in all networks was tested twice by Fisher's combination procedure [47], once for the right-sided and once for the left-sided test. The right-sided test, for example, examines the null hypothesis that in all networks the coefficient of this effect is non-positive, while the alternative hypothesis is that in at least one school the coefficient is positive. To control for multiple (right and left) testing, there was deemed to be significant support for an effect if either of these combination tests were significant at the 0.025 level. This Fisher's combination procedure [47] is preferred over the Snijders–Baerveldt method [30], as it does not make the assumption that estimated standard errors and parameter values are uncorrelated, nor the assumption that the networks are a sample of a population.

The null hypothesis, that effect parameters are constant across schools, was tested by Cochran's method [48], adapted for network dynamics by Snijders & Baerveldt [30,48].

To examine differences between male and female networks, within each school parameter results of the male and female networks were compared with an independent-sample *t*-test. The results of these nine *t*-tests were then combined using Fisher's combination procedure [47], assuming a significance level of 0.025.

#### **Differences between reciprocal and non-reciprocal friendships**

To explore whether the strength of smoking-based selection of friends differs when selecting non-reciprocal or reciprocal friends, and whether influence of friends differs within non-reciprocated and reciprocated friendships, interaction effects of smoking-based selection and

**Table 1** Included effects for modelling selection and influence processes simultaneously.

	<i>Description</i>
Network decision: selection processes	
Smoking behaviour ego	Main effect of the adolescent's own smoking behaviour on selection of friends
Smoking behaviour alter	Main effect of potential friends' smoking behaviour on selection of friends
Smoking behaviour alter squared	Main effect of potential friends' squared smoking behaviour on selection of friends
Smoking behaviour ego $\times$ alter	Tendency to choose a friend based on similar smoking behaviour
Outdegree	General tendency to choose a friend
Reciprocity	Tendency to have reciprocal friendships
Transitivity*	Tendency to become a friend of a friends' friend
Alcohol consumption ego	Main effect of the adolescent's own alcohol consumption on selection of friends
Alcohol consumption alter	Main effect of potential friends' alcohol consumption on selection of friends
Alcohol consumption alter squared	Main effect of potential friends' squared alcohol consumption on selection of friends
Alcohol consumption ego $\times$ alter	Tendency to choose a friend based on similar alcohol consumption
Age ego	Main effect of the adolescent's own age on selection of friends
Age alter	Main effect of potential friends' age on selection of friends
Age ego $\times$ alter	Tendency to choose a friend based on similar age
School achievement ego	Main effect of the adolescent's own school achievement on selection of friends
School achievement alter	Main effect of potential friends' school achievement on selection of friends
School achievement ego $\times$ alter	Tendency to choose a friend based on similar school achievement
Extra effect tested with score test	
Smoking behaviour ego $\times$ alter $\times$ reciprocity	Effect to test whether selection based on similar smoking behaviour differs when selecting reciprocal or non-reciprocal friends
Behaviour decision: influence processes	
Smoking behaviour friends**	Main effect of friend's smoking behaviour on his own smoking behaviour
Incoming friendships	Main effect of adolescents' number of nominations by others on his own smoking behaviour
Outgoing friendships	Main effect of adolescents' number of nominated friends on his own smoking behaviour
Tendency to smoke	General tendency to smoke
Tendency to smoke squared	Feedback effect of adolescent's own smoking behaviour on itself
Smoking behaviour parents	Main effect of parental smoking behaviour on own smoking behaviour
Smoking behaviour siblings	Main effect of siblings' smoking behaviour on own smoking behaviour
Alcohol consumption adolescent	Main effect of an adolescent's alcohol consumption on own smoking behaviour
Age adolescent	Main effect of an adolescent's age on own smoking behaviour
School achievement adolescent	Main effect of an adolescent's school achievement on own smoking behaviour
Extra effect tested with score test	
Smoking behaviour of friends $\times$ reciprocity	Effect to test whether the effect of friend's smoking behaviour differs among reciprocal and non-reciprocal friends

\*Transitive ties; \*\*average alter effect. Adequately controlling for attributes, such as age, results in a larger number of effects included in the friendship evolution part compared to the smoking behaviour evolution part. This difference is due to the multi-dimensional nature of selection processes. The probability to select a friend may depend upon the age of the adolescent, the age of the potential friend and similarities in age of both. The effect of age on adolescent smoking behaviour can be modelled by including only the effect of adolescents' age on their own smoking behaviour.

influence of friends with reciprocity were tested with score tests [31, M. Schweinberger, unpublished data].

### The relative contribution of smoking-based selection and influence

As a similarity measure of individuals linked in a network we used Moran's *I*, a spatial autocorrelation coefficient [49]. By calculating the average similarity of linked individuals in simulated models with coefficients estimated under different model specifications, the relative contributions of selection, influence and control effects to

observed smoking similarity can be expressed. This method is explained in detail elsewhere [42,50]. Two male networks were excluded ( $n = 92$ ) due to very low smoking rates (mean smoking behaviour  $<0.5$ ), which might bias the results of these simulations. For comparative purposes the two female networks within these schools were also excluded ( $n = 123$ ). We will represent graphically average proportions of similarity allocated to smoking-based selection, peer influence, selection and influence mechanisms not based upon links between friendship and smoking (i.e. controls), and general trend effects (previous friendships and smoking behaviour).



**Table 2** Descriptive statistics of network structure of schools and individual characteristics.

	Males	Females	P-value*	
Average network structure within schools				
Average number of adolescents	67	62	0.289	
Average number of friends				
Wave 1	1.42	1.75	0.203	
Wave 2	1.85	2.45	<b>0.012</b>	
Wave 3	2.02	2.61	0.098	
Wave 4	2.33	2.85	0.359	
Average % friendship ties within the same school grade	0.46	0.52	0.098	
Reciprocity fraction				
Wave 1	0.43	0.46	0.820	
Wave 2	0.31	0.51	<b>0.012</b>	
Wave 3	0.39	0.40	1.000	
Wave 4	0.31	0.43	<b>0.047</b>	
Transitivity index				
Wave 1	0.21	0.26	0.250	
Wave 2	0.16	0.34	<b>0.004</b>	
Wave 3	0.16	0.26	<b>0.039</b>	
Wave 4	0.24	0.26	0.359	
Moran's I network autocorrelation index				
Wave 1	0.31	0.32	0.820	
Wave 2	0.28	0.37	0.310	
Wave 3	0.40	0.45	1.000	
Wave 4	0.41	0.44	0.820	
Individual characteristics				
Mean smoking behaviour adolescent				
Wave 1	0.35	0.47	0.359	
Wave 2	0.74	0.99	0.203	
Wave 3	1.35	1.37	0.652	
Wave 4	1.37	1.46	0.570	
Mean % missing smoking behaviour	2.63	2.65	0.734	
Alcohol consumption adolescent	0.31	0.25	0.129	
Mean percentage at least one smoking parent	46.12	54.59	<b>0.027</b>	
Mean percentage at least one smoking sibling	18.94	27.10	<b>0.027</b>	
Mean age baseline (in years)	13.62	13.57	0.426	
Mean school achievement	1.94	2.01	0.250	
Friendship ties	Wave 1	Wave 2	Wave 3	Wave 4
% Friendship ties between males	43.22	37.43	32.01	31.32
% Friendships ties between females	54.97	58.78	62.90	63.48
% Excluded cross-gender friendship ties	1.81	3.78	5.09	5.20

\*Exact two-sided *P*-value Wilcoxon signed-rank test at school level ( $n = 9$ ), bold-type values represent significant results; smoking behaviour is coded as follows: 0: no cigarettes each week; 1: between none and one; 2: two to 10; 3: 11–30; 4: >30. Alcohol consumption is coded as follows: 0: no glasses alcohol each week; 1: one to two; 2: three to five; 3:  $\geq$  five. School achievement is coded as follows: 1: among the lower third of the class; 2: middle third; 3: best third.

## RESULTS

### Descriptives

Table 2 presents the average network structure within male and female networks, the average smoking behaviour in each wave and baseline characteristics. Males and females smoked at similar rates. Females nominated more friends at wave 2 and reported more often to have smoking parents and siblings.

### Differences between male and female networks: selection processes

The results for the friendship evolution submodel are reported in the upper part of Table 3. Males and females tended to nominate more smoking friends when their own smoking behaviour was higher, as indicated by the significant 'smoking behaviour ego  $\times$  alter' effects. There were no significant effects of adolescent

**Table 3** Meta-analysis results: estimates, *P*-values and differences between schools of the combined model.

	Males ( <i>n</i> = 605)				Females ( <i>n</i> = 558)				Difference test*	
	Estimate	OR	<i>P</i> -values		Estimate	OR	<i>P</i> -values		<i>P</i> -values	
			Left	Right			Left	Right	Left	Right
Friendship network change										
Smoking behaviour ego	-0.048	0.953	0.286	0.794	-0.036	0.965	0.144	0.889	0.862	0.716
Smoking behaviour alter	0.070	1.073	0.636	0.445	0.063	1.065	0.620	0.046	0.395	0.661
Smoking behaviour alter squared	-0.055	0.946	0.261	0.833	-0.027	0.973	0.058	0.839	0.631	0.416
Smoking behaviour ego × alter	<b>0.116</b>	1.123	1.000	0.000	<b>0.110</b>	1.116	1.000	0.000	0.844	0.468
Outdegree	<b>-2.239</b>	0.107	0.000	1.000	<b>-2.454</b>	0.086	0.000	1.000	0.380	0.793
Reciprocity	<b>1.433</b>	4.191	1.000	0.000	<b>1.486</b>	4.419	1.000	0.000	0.665	0.580
Transitivity	<b>1.083†</b>	2.954	1.000	0.000	<b>1.335†</b>	3.800	1.000	0.000	<b>0.011</b>	0.480
Alcohol consumption ego <sup>a</sup>	0.048	1.049	0.311	0.481	-0.104	0.901	0.056	0.945	0.816	0.387
Alcohol consumption alter	-0.306	0.736	0.054	0.985	<b>0.239†</b>	1.270	0.553	0.000	0.038	0.934
Alcohol consumption alter squared	0.081	1.084	0.955	0.318	<b>-0.110†</b>	0.896	0.009	0.525	0.919	0.125
Alcohol consumption ego × alter	0.155	1.168	0.925	0.089	0.087	1.091	0.785	0.351	0.679	0.598
Age ego	-0.191	0.826	0.142	0.923	-0.066	0.936	0.415	0.722	0.421	0.861
Age alter	-0.022	0.978	0.515	0.877	-0.011	0.989	0.358	0.593	0.492	0.640
Age ego × alter	0.191	1.210	0.783	0.545	0.176	1.192	0.873	0.503	0.682	0.741
School achievement ego <sup>a</sup>	0.045	1.046	0.641	0.303	0.052	1.053	0.942	0.257	0.495	0.750
School achievement alter	<b>-0.122†</b>	0.885	0.002	0.923	0.042	1.043	0.942	0.222	0.060	0.963
School achievement ego × alter	0.050	1.051	0.689	0.216	0.014	1.014	0.732	0.469	0.699	0.562
Smoking behaviour change										
Smoking behaviour friends	0.030†	1.030	0.492	0.074	<b>0.062†</b>	1.064	0.580	0.002	0.239	0.869
Incoming friendships	-0.028	0.972	0.404	0.578	0.030	1.030	0.850	0.222	0.392	0.727
Outgoing friendships	<b>-0.208</b>	0.812	0.000	0.994	<b>-0.237</b>	0.789	0.000	0.958	0.295	0.517
Tendency to smoke	<b>-0.464†</b>	0.629	0.000	1.000	<b>-0.241†</b>	0.786	0.019	0.690	0.135	0.756
Tendency to smoke squared	<b>0.396</b>	1.486	1.000	0.000	<b>0.377</b>	1.458	1.000	0.000	0.808	0.414
Smoking behaviour parents <sup>a</sup>	<b>0.414†</b>	1.513	0.982	0.000	<b>0.339</b>	1.404	0.920	0.004	0.581	0.208
Smoking behaviour siblings <sup>a</sup>	0.229	1.257	0.981	0.082	0.190	1.209	0.701	0.324	0.895	0.493
Alcohol consumption adolescent <sup>a</sup>	<b>-0.159†</b>	0.853	0.000	0.973	<b>-0.253†</b>	0.776	0.017	0.380	0.203	0.914
Age adolescent	0.025	1.025	0.341	0.329	-0.087	0.917	0.247	0.808	0.831	0.665
School achievement adolescent <sup>a</sup>	0.009	1.009	0.520	0.313	<b>-0.123†</b>	0.884	0.018	0.600	0.734	0.300

*n*: Number of adolescents; estimate: unstandardized coefficients according to the Snijders–Baerveldt method (2003); OR: odds ratio; *P*-values: Fisher's combination of one-sided tests; bold-type values represent significant results; <sup>a</sup>attributes modelled as changing covariates; \*independent-sample *t*-tests combined with Fisher's combination of one-sided tests; †significant differences found between schools according to the Snijders–Baerveldt method (2003).

own smoking and smoking of potential friends on friendship selection.

Results for the control effects indicate that males and females tended to choose relatively few friends (outdegree) to reciprocate friendships (reciprocity), and to become friends with friends of their friends (transitivity). Adolescents did not select friends based upon similar alcohol consumption, age or school achievement. Among males, a propensity to select low-achieving friends was found, while females tended to select friends drinking alcohol at medium level (preferred scale value 1). Only transitivity differed significantly between males and females (combination left-sided tests  $\chi^2 = 34.46$ , *df* = 18, *P* = 0.01), implying that females showed a stronger tendency to select friends of their friends.

#### Differences between male and female networks: influence processes

Results of the smoking behaviour evolution submodel are reported in the lower part of Table 3. Females were influenced by their friends' smoking behaviour. Although there was evidence that the magnitude of effect of friend's smoking behaviour differed across the nine included female networks [ $\chi^2 = 25.43$ , *df* = 8, *P* = 0.001, estimated true standard deviation (SD) = 0.000], the effect was found to be consistently positive (right-sided *P* = 0.002, left-sided *P* = 0.58). Although males and females did not differ significantly, males did not adjust their smoking behaviour significantly to their friends' smoking behaviour. However, there was evidence for

some variation in the effects across the male networks ( $\chi^2 = 16.33$ ,  $df = 8$ ,  $P = 0.038$ , estimated true SD = 0.000). Both males and females who nominated fewer friends tended to smoke more.

The control effects indicated that adolescents had a significant overall tendency not to smoke, but smoking behaviour tended to be self-reinforcing, as indicated by the significantly positive 'tendency to smoke squared' effect. Male and female adolescents smoked more when their parents smoked and when they drank less alcohol. Females smoked significantly more when they were low achievers. High-achieving males had a higher tendency to smoke, but this effect was not significant. None of these effects differed significantly between males and females.

#### Differences between reciprocal and non-reciprocal friendships

The score test of the interaction between smoking of adolescents, friends and reciprocity indicated that in male and female networks, the tendency to select reciprocal or non-reciprocal friends who are similar in smoking behaviour did not differ (combination left-sided tests  $\chi^2$  males = 20.53,  $df = 18$ ,  $P = 0.30$ , females = 29.07,  $df = 18$ ,  $P = 0.05$ ; combination right-sided tests  $\chi^2$  males = 11.54,  $df = 18$ ,  $P = 0.87$ , females = 12.77,  $df = 18$ ,  $P = 0.81$ ).

The score test of the interaction between friends' smoking and reciprocity in its effect on smoking dynam-

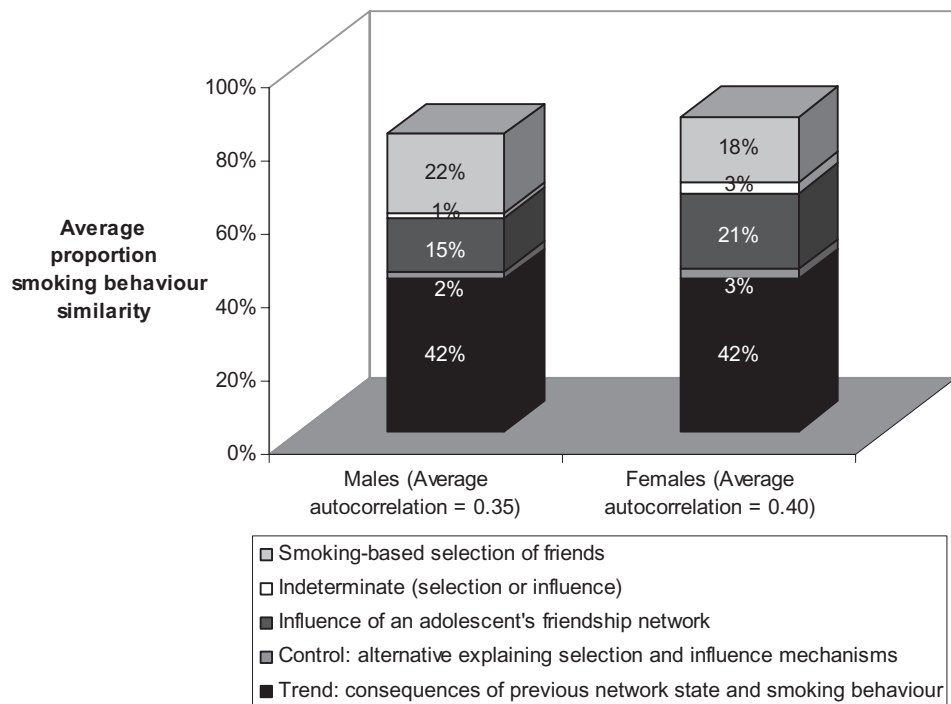
ics showed that among males and females influence of friends did not differ between reciprocal and non-reciprocal friendships (combination left-sided tests  $\chi^2$  males = 13.34,  $df = 18$ ,  $P = 0.77$ , females = 7.72,  $df = 18$ ,  $P = 0.98$ ; combination right-sided tests  $\chi^2$  males = 23.86,  $df = 18$ ,  $P = 0.16$ , females = 22.39,  $df = 18$ ,  $P = 0.22$ ).

#### The relative contribution of smoking-based selection and influence

Figure 1 shows that the mean proportion of similarity in smoking behaviour between friends attributed to smoking-based friendship selection was 22% for males and 18% for females. The mean proportion attributed to influence of friendship networks was 15% for males and 21% for females. Trend effects (previous state of friendships and smoking behaviour) accounted for 42% in male and female adolescents, and other determinants of friendship and smoking played only a small role in the explanation of smoking behaviour similarity.

#### DISCUSSION

The main goal of this study was to examine differences between adolescent male and female friendship networks regarding smoking-based selection and influence processes using newly developed tools of social network analysis.



**Figure 1** The relative contribution of smoking-based selection and influence on similarities in smoking. Note: the model explained 82% of smoking behaviour similarity among males, 87% among females



We found evidence that males and females formed friendships based on similarities in smoking behaviour. This process was similar for adolescent males and females. These results are in line with our hypothesis and earlier research reporting peer selection to be important in explaining similarities between adolescent friends with respect to smoking [11,13–17]. However, no study examined smoking-based selection processes specifically in gender-segregated friendship networks.

We found empirical support for influence of friends with respect to smoking behaviour within female networks. This effect was not significant among males. Although our findings seem in line with previous studies, suggesting that girls perceive more social pressure [25] and are more susceptible to social influences [26], the difference between males and females was not significant and parameter estimates were such that a relatively large amount of the smoking behaviour similarity among male friends was explained by influence (Fig. 1). The lack of strong support for influence processes within male networks might be explained by males fostering friendship intimacy through sharing activities with friends [51], which takes place mainly outside school. Out-of-school friends may exert a stronger influence compared to within-school friends. Further research with a larger database is needed to give more unequivocal results about male–female differences in this respect, and to study dependencies of these differences on school context.

There was no evidence that reciprocation of friendship modified the effect of smoking similarity on friendship choice. In contrast with previous studies reporting stronger support for influence processes among reciprocal friends [52,53], the strength of influence processes did not differ significantly between reciprocal and non-reciprocal friendships in the present study. However, researchers found support for influence among reciprocal [12,52,53] and non-reciprocal friends [10,54] among different populations. More research is needed to clarify the specific role of friendship reciprocity.

Besides smoking-based selection, we controlled for several alternative processes explaining peer selection. Only transitivity differed significantly between males and females, indicating that females showed a higher tendency to select friends who were friends of their friends. Males and females were similar in their tendency to select arbitrary friends and reciprocate friendships. Furthermore, females preferred to select females who reported medium scores on alcohol consumption. In contrast with findings of previous studies [27], no support was found for selection based upon similar alcohol consumption. However, as findings on the complete Finnish sample showed support for adolescents selecting their friends based on similar alcohol consumption [50], lack of support may be caused by the reduced sample size due to

restricting the networks to solely males or females. In line with earlier studies arguing that boys' culture is less study-orientated [55], and school achievement is not considered to be 'cool' among boys [56,57], males preferred to select males scoring low on school achievement.

Regarding alternative influence mechanisms, no significant gender differences were found. Females smoked more when they scored low on school achievement. In line with previous studies, males and females were influenced by parental smoking [17,25,29]. Although previous research has demonstrated that tobacco use predicts subsequent alcohol use more effectively than the converse [58], the negative effects of alcohol consumption on smoking were counterintuitive. Complete-sample in-depth analyses confirmed the significant negative effect during the first wave, but this effect lost significance during the second wave and became positive, although not significant, during the last wave. Alcohol is very expensive in Finland. Lack of sufficient resources at a very young age may have forced youngsters' to choose between smoking or alcohol.

The following limitations of this study can be reported. First, self-reported smoking behaviour was not validated biochemically. However, self-reported smoking can correspond well with biological indicators under measurement conditions assuring anonymity [59]. The ESFA project optimized measurement conditions by guaranteeing confidentiality [32]. Secondly, data were gathered from the Helsinki area only. Further research should illuminate differences between urban and rural areas. Thirdly, we included only friendships within the same school grade. Although these friends represent an important part of adolescents' social environment, future studies should include out-of-school friendships. Fourthly, previous research has demonstrated that parents can also have an effect on the types of friends that adolescents select [60]. The role of parenting styles and practices in smoking-based selection processes should also be studied using actor-based modelling techniques. Fifthly, several included constructs were measured with one item. Future studies should include variables based on multiple questions to increase reliability and validity. Sixthly, although adolescents can report parental smoking reliably [61] our results might be biased, as no direct measures of parental and sibling smoking were available. Finally, we did not consider possible differences between the successive data waves. However, a previous study on the same data set indicated no differences in smoking-based selection and influence effects between the three waves [50].

This study has several practical implications. First, both male and female adolescents selected friends based upon similar smoking behaviour, implying that prevention programmes for adolescent males as well as females

should focus upon selection processes. Previous studies have already demonstrated the importance of peer networks besides the focus on social influences [62,63]. Although more research is needed on the relation between attitudes and selection processes, reinforcing non-smoking attitudes among males and females might be a way to increase the likelihood that they select non-smoking peers. Secondly, only females were influenced significantly by their friends to take up smoking and should therefore benefit from learning skills to resist influence of friends. Although support for influence of friends among males was weak, the effects between males and females did not differ significantly and we therefore cannot conclude that prevention programmes will benefit from targeting adolescent males and females in a different way. Thirdly, as both males and females were influenced by parental smoking, the nature of this link should be investigated in more detail to learn how parents should be involved in youth smoking prevention programmes.

#### Declarations of interest

None.

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